5.2.3. Controls and Displays

5.2.3.1. Purpose

The purpose of this test is to assess the suitability and utility of the SMS controls and displays for the assigned mission as an interface between the operator and the aircraft stores.

5.2.3.2. General[16]

The controls and displays must be usable in every conceivable flight regime, ambient lighting condition, weather condition, and by aviators with the range of anthropometric measurements for which the system was designed to operate. For the modern fighter or attack airplane this is usually all weather, day or night, around +9 to -4 gs, for the 3 to 98 percentile groups, and in a realistic tactical environment filled with urgent decisions demanding the aviator's attention. For this reason, the controls and display should require an absolute minimum of operator input or interpretation and the information imparted and required from the operator should be a minimum and precisely what the aviator needs to execute the current phase of flight.

The SMS is typically required at the very peak of the pilot workload. The SMS is used just at weapons delivery, when both the defensive and offensive requirements are at a maximum, and during emergencies when stores have to be quickly jettisoned. For this reason, it is preferable to perform SMS setup and optimization on the ground at engine start or during a relatively low workload portion of the flight.

Controls should be easily manipulated wearing the proper flight clothing. The range of control (both the physical range of movement of the knob, dial, lever, etc. and the range of effect that the control has on the SMS) and sensitivity should be compatible with the expected flight regime. Controls that require manipulation while airborne should be reachable from the DEP, particularly if they must be activated in a combat environment. As an example, the chaff and flare controls must be reachable while performing high g maneuvers and while maintaining a body position ready for safe ejection. The operative sense must be correct. The direction of activation should conform to the standards of common sense (turn the knob to the right to turn on the system) and to the standards set in references 13 and 14 (which for the most part merely put on paper the standards of common sense). The operation of the controls should be clear, requiring a minimum of operator concentration and attention. This leaves the operator free to make tactical decisions. The controls should also be placed in logical functional groups, reducing the area of scan required to check the SMS set up.

The SMS controls should be integrated well into the cockpit. Correct integration requires that the controls should operate harmoniously with the other controls within the cockpit and without hindering the simultaneous operation of other airplane systems. Integration must be evaluated during a mission relatable workload and while simultaneously operating all the other airplane systems. Typically, the majority of the SMS manipulations should be performed before the workload for the mission peaks to allow real-time use of the other systems.

Lastly, the controls should provide good tactile feedback. For example, detents should provide the proper amount of "click" and all the knobs shouldn't feel exactly alike when reaching for a control with the pilot's attention elsewhere. Applying a little common sense and manipulating the controls in a mission relatable environment usually uncovers most of the control human factors violations.

The SMS status displays should be clearly visible from the DEP in bright daylight as well as complete darkness. In bright daylight, the display must be usable under all conditions of glare, including sunlight directly over the operator's shoulder onto the display (a particularly serious problem for most displays). In the dark, the display should not be so bright that it distracts the operator or affects his or her night vision. A good range of

[16]For an introduction into controls and displays human factors, see references 20, 54 and 73.

brightness control that integrates harmoniously with the rest of the cockpit is required.

The display resolution must be adequate. The display must refresh itself quick enough so that the symbology, alphanumerics and video present an even and continuous display without noticeable flicker. There should be no visible delay between the update of the SMS data and the update of the symbology, graphics and alphanumerics. For example, the display should update rapidly following operator inputs or after stores are launched or jettisoned, reflecting the new status.

Alphanumerics must be clear and legible. The messages should be short and easily understood without excessive coding or operator interpretation. The information displayed to the operator including graphics, symbols and alphanumerics must be sufficient for the current phase of flight while at the same time not overloading the operator with information. This usually requires tailoring the display to the specific attack mode/mission/phase of flight, that is currently being used. The display should be assessed for the information load in a mission relatable scenario to determine its utility as an aid in the combat environment. The use of graphics to show loads and configurations of stores is particularly useful in SMS displays. A line drawing with recognizable stores attached to the appropriate stations provides a very compact and easily interpreted presentation.

It is unlikely that a display compatible in size, weight, power and cooling requirements with a tactical airplane will be built in the near future that has too large of a usable display face. Almost all displays are too small for the task and as such should be evaluated for size in a relatable mission environment, accounting for this element of realism.

The display should be positioned in a location suitable for the mission. As an example, an SMS display which must be manipulated in real time to select the correct mix and mode for chaff and flares should be high on the front panel or on the HUD to allow the pilot to make the selections, while at the same time minimizing the time he or she spends with his or her eyes in the cockpit and consequently away from a visual scan for the threat. As with controls, display human factors problems typically surface by applying a little common sense while using the SMS in a mission relatable scenario.

5.2.3.3. Instrumentation

A tape measure and data cards are required for this test. A voice recorder is optional.

5.2.3.4. Data Required

Record qualitative comments, the evaluator's anthropometric data and a list of personal flight gear worn. The number of display raster lines per inch should be obtained from the SMS technical manual. The usable display area should be measured. Location of the display from the DEP should be measured if a qualitative problem is noted. Record the reach length of controls that are beyond the operator's reach while seated at the DEP during any mission relatable scenario.

5.2.3.5. Procedure

Find the DEP as outlined previously. All ground and airborne tests should be performed while at this position and wearing a complete set of flight gear. Perform a system turn up, on the ground outside of the hangar, in a range of ambient lighting conditions (bright daylight to darkness which may be simulated using a canopy curtain). Manipulate all controls noting the factors discussed above. Measure the display usable area. Evaluate the display for the factors discussed above. Measure and note the position and reach length to all controls and displays that pose a visibility or reach problem from the DEP. During airborne testing, manipulate the controls and make qualitative comments during mission attacks and intercepts. Take particular note during extremes of ambient lighting for displays and during high g maneuvers for controls. Confirm the results of the ground tests while airborne. Check the extremes of control limits and sensitivity. Repeat for each test flight.

5.2.3.6. Data Analysis and Presentation

Present a table of the operator's anthropometric data and the personal flight equipment worn during the tests. Present the seat position as the number of inches from the bottom of the seat travel. Relate the sensitivity of the controls to the tactical environment in which they are to be used. Relate the accessibility, placement and grouping of

the controls under mission relatable conditions. A chaff and flares mode selector must be readily accessible while scanning outside the airplane and maneuvering violently. Relate the control clarity, operative sense and tactile feedback to a multiple threat, combat scenario requiring the operator to make quick tactical decisions. If ambient lighting affects the display in any way, relate this to the limits of the possible combat environments.

The display resolution should not hinder the legibility of the graphics, symbols and alphanumerics. Relate the information load presented the operator to the combat scenario discussed above and evaluate whether the needed information is present and whether too much information is cluttering the display. This concept is closely related to the size of the display face usable area. A large display can present more information without cluttering the display and requires less concentration to read and evaluate. The refresh rate should be related to the concentration required to evaluate a flickering display. The display position should be evaluated in the context of the type of information displayed, the eye position required for using the display and the display position's effect upon the scan of other displays, instruments and the outside world.

5.2.3.7. Data Cards

Sample data cards are presented as cards 71 and 72.

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CARD NUMBER ____

CONTROLS

CLARITY OF OPERATION:

ACCESSIBILITY (MEASURE REQUIRED REACH IF A PROBLEM):

OPERATIVE SENSE:

ADJUSTMENT SENSITIVITY:

RANGE OF ADJUSTMENT:

TACTILE FEEDBACK:

FUNCTIONAL LOCATION/GROUPING (SKETCH IF A PROBLEM):

INTEGRATION:

Card 71: Controls Data Card

CARD NUMBER ____

DISPLAYS

[PERFORM IN BRIGHT DAY TO DARKNESS]

LOCATION QUALITATIVE COMMENTS (MEASURE LOCATION IF A PROBLEM):

CONTRAST/BRIGHTNESS/GAIN CONTROLS (RANGE OF EFFECTIVENESS):

GLARE (BOTH FROM OUTSIDE AND INSIDE COCKPIT LIGHT SOURCES):

RASTER LINES/INCH:

USABLE DISPLAY AREA ____X____

RESOLUTION QUALITATIVE COMMENTS:

REFRESH RATE QUALITATIVE COMMENTS:

LOCATION OF SYMBOLOGY/ALPHANUMERICS/GRAPHICS:

INTERPRETATION OF SYMBOLOGY/ALPHANUMERICS/GRAPHICS:

INTEGRATION:

Card 72: Displays Data Card